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ART. XII.—*The Stromatoporoids of the Lilydale Limestone.  
Part I. Actinostroma and Clathrodictyon.*

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**Index of Contents.**

INTRODUCTION.

PREVIOUS RECORDS.

DESCRIPTION OF SPECIES.

*Actinostroma compactum*, sp. nov.*A. verrucosum* (Goldfuss).*A. altum*, sp. nov.*Clathrodictyon regulare cylindriferum*, subsp. nov.*C. chapmani*, sp. nov.*C. calamosum*, sp. nov.

BIBLIOGRAPHY.

**Introduction.**

Hitherto little work has been done on Victorian stromatoporoids, though a very rich stromatoporoid fauna of Silurian age is preserved in the Lilydale limestone. The forms described are represented mainly by fragments, and therefore external characters are not readily discernible, but it is hoped that they will be easily distinguished by their microscopic structure as seen in thin sections. The skeletal structure has been little affected by recrystallization, so that the species are readily compared with those described by other authors. In this and following papers, I propose to describe the Lilydale stromatoporoid fauna, beginning with the species of *Actinostroma* and *Clathrodictyon*.

I am indebted to the Director, Mr. D. J. Mahony, M.Sc., and the Palaontologist, Mr. R. A. Keble, F.G.S., of the National Museum, Melbourne, for placing the National Museum collection of Lilydale stromatoporoids in my hands for description. My thanks are also due to Mr. F. Chapman, A.L.S., &c., who had earlier commenced a study of this collection, and had already recognized the presence of several new species, for his assistance in carrying out this work, and to Professor Skeats for facilities for study in the Melbourne University Geological Department, whose collections have also been made available to me.

**Previous Records.**

No specific records of stromatoporoids from Lilydale have been made. F. Chapman (1913), in listing the Silurian Faunas of Victoria, recorded the occurrence of the chief genera of the

stromatoporoids in the Yeringian assemblage, the principal locality being Lilydale. Stromatoporoids, including *Clathrodictyon regulare* (Rosen), from Deep Creek, Walhalla (Chapman, 1914), and (?) *Clathrodictyon* from Wombat Creek, near Glen Wills (Chapman, 1912), have also been recorded from Yeringian limestones in Eastern Victoria.

### Description of Species.

#### Order STROMATOPOROIDEA.

#### Family ACTINOSTROMATIDAE Nicholson (emend. Stechow, 1922).

Mon. Brit. Strom. Pt. I. (Introduction), p. 74, 1886 (Pal. Soc.). Archiv. fur Naturgeschichte, Abt. A., lxxxviii., p. 151, 1922.

#### Genus **Actinostroma** Nicholson, 1886.

Mon. Brit. Strom., Pt. I. (Introd.), p. 75, 1886.

#### ACTINOSTROMA COMPACTUM, sp. nov.

(Figs. 5A, 5B.)

*Actinostroma compactum* Chapman, MS. (Nat. Mus. Labels).

External characters not observed, as the species is represented by two small fragments.

Radial pillars, 5-6 per mm., horizontal laminae, 5 per mm. The skeletal mesh is quadrate and regular. The pillars show in tangential sections a small axial canal. The horizontal laminae, which are gently curved and fairly short, are grouped into latilaminae two or three centimetres broad. The laminae of one latilamina often show a marked overlap on those of the previous one, while the radial pillars are interrupted. Each latilamina must therefore represent definite growth stage in the building of the coenosteum.

Astrorhizae are not observed in vertical sections, as the horizontal canals are not sufficiently differentiated in size from the ordinary skeletal mesh. Tangential sections show that astrorhizae are abundant, but rather irregular in their development. The horizontal laminae are domed at intervals, and a section showing a whole astrorhizal system is not obtainable. It is probable, from the absence of definite cylinders with axial canals, that the astrorhizal systems were not superimposed.

Remarks.—This species is closely related to *Actinostroma clathratum* Nich., and particularly to the type variety occurring in the Middle Devonian of Germany (Nicholson, 1888, p. 133). It is separated from this variety, and from its representative in the

Nemingha limestone of New South Wales—*A. australe*, Dun (see Benson, 1918), by the closer crowding of the radial pillars and horizontal laminae, and by the fairly regular doming of the laminae, which would produce mamelons on the surface. Nicholson (1891) has described two species related to *A. clathratum* occurring in the Devonian of Canada; in *A. expansum* Hall and Whitefield, the laminae are flexuous and domed into broad low eminences, but the skeletal structure of *A. compactum* is much more regular. *A. whiteavesii* Nich., is at once separated from our species by the characteristic "areolated" aspect of tangential sections, which show the radial pillars to be joined by a network of radiating processes almost as thick as the pillars themselves. In vertical sections the skeletal mesh of *A. whiteavesii* Nich., is seen to be quite distinct since the radial pillars are much more crowded than the horizontal laminae.

Horizon and Locality.—Silurian (Yeringian) Mitchell's Quarry, Cave Hill, Lilydale, Victoria.

Four Examples.—No. 13742 (Holotype). No. 13743. Pres. J. S. Green, Esq., 7.8.11, in the collection of the National Museum, Melbourne. No. 13744. Pres. J. S. Green, Esq., 5.7.12. One example in the collection of the Melbourne University Geological Department, Reg. No. 767.

#### ACTINOSTROMA VERRUCOSUM (Goldfuss).

(Figs. 5c, 5d, 1.)

*Cerriopora verrucosa* Goldfuss, Petref. Germ., p. 33, taf. X., fig. 6, 1826.

*Actinostroma verrucosum* Goldfuss. Nicholson. Ann. Nat. Hist., Ser. 5, xvii., p. 228, 1886, and Mon. Brit. Strom., II., p. 134, pl. xvi., figs. 1-8, 1888 (*cum syn.*).

The external characters of the coenosteum are not recognizable, since the species is represented only by a fragment. It was probably massive.

The skeletal mesh, as seen in vertical sections, is very regularly quadrate, where not affected by the astrorhizal cylinders. The radial pillars, of which there are five per mm., continue apparently indefinitely. The horizontal laminae (4 per mm.) are usually slightly thicker than the radial pillars, though much of this effect is apparent, since the section cuts the laminae obliquely when passing through an astrorhizal cylinder. Occasional rounded meshes, slightly larger than the normal rectangular "interpillar spaces," seem to represent the cross-sections of astrorhizae. The astrorhizal cylinders are a characteristic feature of vertical sections; the horizontal laminae are bent upwards at intervals of about 1 cm. to form domes (which would appear as mamelons on the surface) having axial canals. These are transversely divided by "tabulae," which are convex towards the upper surface of the

coenosteum, orienting the section by means of the cylinders, and continuous with the horizontal laminae, so that they were probably deposited at the same time. The axial canals of the astrorhizal cylinders have no proper walls, being bounded by the radial pillars. These are at all times normal to the laminae, so that in sections passing through the centre of a cylinder they are seen to have a pinnate arrangement, with the canal as axis (see Fig. 1). Astrorhizae, in longitudinal section, may pass into the axial canals of the cylinders. The former are of approximately the same diameter as the interlaminar spaces, and are crossed by thin vertical partitions, which are easily distinguished from the much stouter radial pillars.

The tangential section (Fig. 5b) shows a skeletal mesh typical of *Actinostroma*. The radial pillars are apparently solid, and are connected by regularly distributed horizontal processes, giving a polygonal mesh. The quadrate type of mesh characteristic of

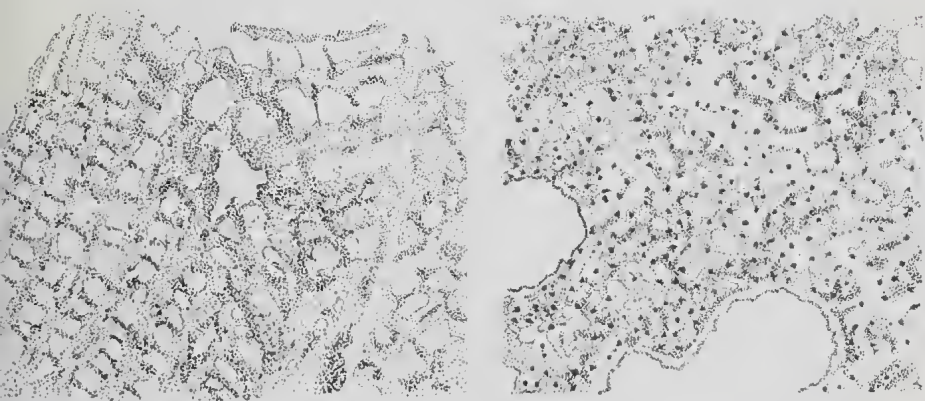


FIG. 1 (left).—*Actinostroma verrucosum* (Goldfuss). Vertical section passing through an astrorhizal cylinder. Coll. Melbourne University Geological Department, Reg. No. 1446.  $\times 13.5$ . FIG. 2 (right).—*Actinostroma altum*, sp. nov. Tangential section showing the crowding of the radial pillars near tubes belonging to another organism. Coll. National Museum, Melbourne. Reg. No. 13745.  $\times 13.5$ .

vertical sections is also seen, as well as many types intermediate between the two extremes, since the laminae are deposited concentrically around the axes of the astrorhizal cylinders. The figure shows this distribution of the laminae, and the consequent radial arrangement of the pillars; the structure is practically identical with that shown in Nicholson's Fig. 5 on Plate XVI. of the Mon. Brit. Strom. (Nicholson, 1888).

Remarks.—The skeletal mesh of the Lilydale example is like that of *A. clathratum* and *A. verrucosum*, and the characteristic and numerous astrorhizal cylinders serve to place it in the latter species. Nicholson, in describing *A. verrucosum*, notes that in Europe it is apparently restricted to the Middle Devonian.

Horizon and Locality.—Silurian (Yeringian), Mitchell's Quarry, Cave Hill, Lilydale, Victoria. One example in collection of the Melbourne University Geological Department, Reg. Nos. 1446-7.

ACTINOSTROMA ALTUM, sp. nov.

(Figs. 2, 5E, 5F.)

*Actinostroma altum* Chapman M.S. (Nat. Mus. labels).

The coenosteum is apparently massive, and divided into "latilaminae" by zones of vesicular tissue. The horizontal laminae are flat or gently curved, showing that the coenosteum must have reached a large size.

Radial pillars, 3-4 per mm. Horizontal laminae, 4-5 per mm. The radial pillars are thin, and somewhat flexuous, and usually pass through only a small number of horizontal laminae. These are thinner than the pillars, and are very interrupted. The lateral horizontal processes given off by the pillars are curved and irregular. Where the fusion of these is incomplete, the horizontal laminae is broken and vesicular. In this character, this species is related to *A. intertextum* Nich. (Nicholson, 1888). The radial pillars are somewhat divergent, and may occasionally branch (Fig. 5E).

In tangential section, the cut ends of the pillars appear as very small rounded dots, which are usually connected by radiating horizontal processes, forming a polygonal network. The denser portions of this network represent the cut edges of the horizontal laminae. Astrorhizae are apparently not present, or if developed, are not sufficiently differentiated to cause more than a slight irregularity in the distribution of the radial pillars (see Fig. 5E). The marginal parts of the tangential section show a doming of the laminae into mamelons, but no definite astrorhizal canals have been observed. Another tangential section shows rounded, irregularly spaced cross sections of tubes about 1 mm. in diameter, which probably belong to another organism. These tubes have definite walls, but show no structure, being completely replaced by calcite. In a narrow zone immediately surrounding each tube, the pillars are more closely packed, and the horizontal connecting processes are more abundant. The doming of the concentric laminae, which usually occurs when a stromatoporoid coenosteum includes foreign bodies, has not taken place. (See Fig. 2.)

Remarks.—*A. altum* is related most closely to *A. intertextum* Nich. (Nicholson, 1888) of the Wenlock limestone (Salopian) of Britain, and the Silurian limestone of Esthonia. From this species it differs mainly in the much greater irregularity of the skeletal mesh; the shorter pillars are generally divergent, often branching, and shorter and stouter than in *A. intertextum*, and

the horizontal laminae are more vesicular. *A. altum* is represented by a small fragment of an apparently massive coenosteum, while *A. intertextum* is laminar in habit.

Horizon and Locality.—Silurian (Yeringian). Mitchell's Quarry, Cave Hill, Lilydale, Victoria, No. 13745 in Nat. Mus. Collection. Purch. A. W. Cresswell, 30.6.02.

### **Clathrodictyon** Nicholson and Murie, 1878.

Nicholson, H. A., and Murie, J. Journ. Linn. Soc. Zool., xiv., p. 220, 1878.

#### CLATHRODICTYON REGULARE (ROSEN).

*Stromatopora regularis* v. Rosen. Ueber die Natur der Stromatoporen, p. 74, pl. ix., figs. 1-4, 1887.

*Clathrodictyon regulare* Rosen sp., Nicholson. Mon. Brit. Strom., II., p. 155, pl. xviii., figs. 8-11A, 1888.

#### CLATHRODICTYON REGULARE CYLINDRIFERUM subsp. nov.

(Figs. 3, 6A, 6B.)

External characters of the Lilydale example not observed, the coenosteum probably reached a larger size than that of the typical form.

Radial pillars, 3-4 per mm. Horizontal laminae, 5-6 per mm. The horizontal laminae are very evenly spaced, undulating, and of the same thickness as the vertical pillars. The mesh produced is regularly quadrate, the "cells" being slightly rounded, since the vertical pillars are somewhat thickened at their junction with the horizontal laminae. Incomplete pillars are rare, and secondary "cells," produced by the bifurcation of the pillars, are not present. The type of skeletal mesh thus agrees very well with that described by Nicholson (1888) for *Clathrodictyon regulare* (Rosen).

Astrorhizae are present, and are arranged in vertical series, producing cylinders. These are shown in vertical section by the regular doming of the horizontal laminae and the presence of vertical canals. The canals are tabulate, the tabulae being co-extensive with the neighbouring horizontal laminae, and occupy the centres of the domes. In places, a horizontal astrorhizal canal is seen to change its direction and traverse an astrorhizal cylinder vertically (see Fig. 6A). As in *Actinostroma verrucosum*, where these vertical canals are also well developed, they have no definite wall, but appear to be bounded by the radial pillars, which, however, are more nearly in vertical series.

In tangential section, the mesh is imperfectly "hexactinellid"; the pillars are small, and are connected by irregular horizontal processes. The horizontal laminae are minutely granular. The most conspicuous feature of tangential sections is the concentric

grouping of the laminae into astrorhizal cylinders. These are traversed by about eight vertical canals, none of which is truly axial. The centre of the astrorhizal cylinder is occupied by irregularly reticulate material, which is much finer than the normal skeletal mesh (Fig. 3).

Remarks.—This subspecies bears probably the same relation to *C. regulare* (Rosen) as does *Actinostroma verrucosum* (Goldfuss) to *A. clathratum* Nich. Boehnke (1915), in describing *C. regulare* (Rosen) from the Silurian erratics of North Germany, has recorded the presence of astrorhizae, which, however, are not organized into vertical systems. Nicholson's specimens from the Wenlock Limestone of Dudley possessed no astrorhizae. *Clathrodictyon retiforme* (Nich. and Murie) possesses well-marked astrorhizal cylinders (Nich. and Murie, 1878, Nicholson, 1887); in *C. variolare* (Rosen), the astrorhizae are small and numerous, and do not correspond to the surface mamelons.

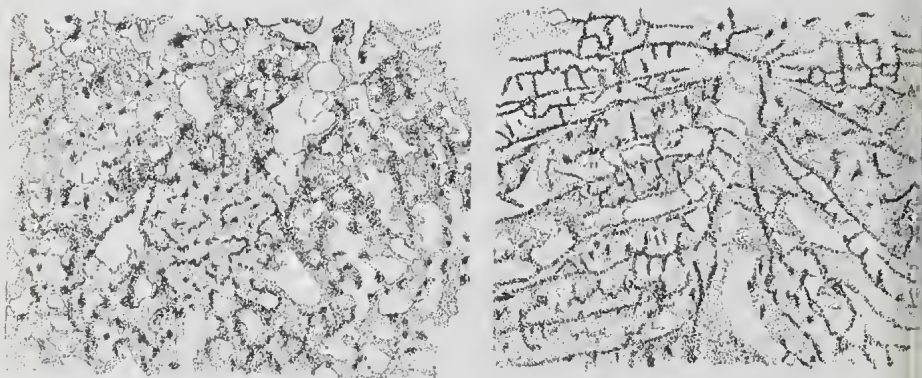


FIG. 3 (left).—*Clathrodictyon regulare cylindrifera*, subsp. nov. Tangential section passing through an astrorhizal cylinder. Coll. National Museum, Melbourne. Reg. No. 13746.  $\times 13.5$ . FIG. 4 (right).—*Clathrodictyon chapmani*, sp. nov. Vertical section passing through an astrorhizal system. Coll. National Museum, Melbourne. Reg. No. 13747.  $\times 13.5$ .

though they are arranged in vertical series (Nicholson, 1888); *C. ostiolatum* (Nich.) has vertical astrorhizal canals, which are not connected with the surface mamelons (Nicholson, 1887), and *C. conophoroides*, Eth. fil., of the Upper Silurian of Trundle (N.S.W.) has astrorhizal cylinders ending as surface mamelons, but these have no horizontal canals. *Actinostroma whiteavesii* Nich. of the Devonian of Canada (Nicholson, 1891), likewise has no horizontal astrorhizal canals, and its vertical canals are arranged in rosette-like groups, which occupy the axes of broad eminences. The organization of the astrorhizae is thus similar to that in *Clathrodictyon regulare cylindrifera*, subsp. nov., in which, however, the vertical canals give off horizontal branches. From vertical sections which show gently undulating horizontal

laminae it is probable that prominent mamelons were not developed on the surface of the Victorian form, and the skeletal mesh of our variety is quite distinct from that of any of the above forms. It agrees exactly with that of *C. regulare* (Rosen), and it is considered that the presence of a well-developed astrorhizal system is a subspecific distinction only (Heinrich, 1914).

*C. regulare* (Rosen) is rare in the Wenlock limestone of Britain and Gotland.

Horizon and Locality.—Silurian (Yeringian), Mitchell's Quarry, Cave Hill, Lilydale, Victoria. One example: No. 13746 in the National Museum Coll. Pres. S. R. Mitchell, Esq., 3.12.23.

CLATHRODICTYON CHAPMANI, sp. nov.

(Figs. 4, 6c, 6d.)

The only known example is a fragment of a coenosteum, which was probably massive in habit. The surface characters are unknown, though the curvature of the laminae suggests that astrorhizal mamelons were present.

Vertical sections show that the coenosteum is made up of thin horizontal laminae, which are gently flexed and spaced rather far apart (2-3 per mm.). The wide interlaminae spaces are filled with a reticulated tissue made up of the incomplete radial pillars and their irregular connecting processes, which are given off at different levels. This, however, does not resemble the vesicular tissue of a typical species of *Clathrodictyon*. Astrorhizae are fairly abundant, and grouped into vertical systems. The horizontal canals rise obliquely, following the curve of the laminae forming the mamelon, and join the axial canal of the cylinder. Both the horizontal and vertical canals are tabulate. (See Fig. 4.)

In tangential section, the horizontal laminae are seen to be formed by the vertical pillars and their radiating connecting processes. The pillars are very slender, and therefore are inconspicuous in cross section, while the processes are of approximately the same diameter as the pillars, so that a network of apparently continuous granular skeletal fibres, resembling that described by Nicholson in *Actinostroma whiteavesii* Nich., is produced. Between the laminae the radial pillars are connected by similar processes, but the network is much more open, and corresponds to the reticulate tissue of the interlaminae space. Astrorhizae are abundant, but a complete radiating system is not often seen in tangential section on account of the obliquity of the horizontal canals near the centres of the mamelons.

Remarks.—This species is not related to any described form of *Clathrodictyon*. The tangential section particularly shows a marked difference from other species, since the radial pillars are connected by radiating processes of similar diameter, giving the

areolated appearance seen in tangential sections of *Actinostroma whiteavesii* Nich. (Nicholson, 1891). An essential character of *Clathrodictyon*, according to Nicholson (1885, 1887), is the isolation of the radial pillars. The tangential section of a typical *Clathrodictyon* thus shows only thin cut ends, without the "hexactinellid" or the areolated structures seen in *Actinostroma*. Otherwise, the species agrees well with *Clathrodictyon*. The skeletal fibre is granular, and the horizontal skeletal element is better developed than the radial; in the absence of further material, it is placed in that genus, while noting the differences from more typical species.

Horizon and Locality.—Silurian (Yeringian). Mitchell's Quarry, Cave Hill, Lilydale, Victoria. One example, No. 13747, in Nat. Mus. Coll. Pres. R. H. Annear, Esq., 23.3.10.

CLATHRODICTYON CALAMOSUM, sp. nov.

(Figs. 6E, 6F.)

Preserved only as fragments, weathered surfaces smooth, without conspicuous mamelons. The coenosteum is massive, and built up of successive zones, 5-7 mm. broad, which are emphasized in one of the specimens by differential iron-staining. They do not indicate growth stages, since there is no definite break in the deposition of the laminae, and so cannot be described as latilaminae.

The horizontal laminae, of which there are 4 or 5 in a millimetre, are thin and arched between the radial pillars (3-4 per mm.), but are not crumpled as in *C. variolare* (Rosen). The "cells" so formed are somewhat rounded, and of varying lengths, since the distribution of the radial pillars is irregular. These are stout, and usually tubular; the walls are of the same thickness as the horizontal laminae, and seem to be formed by their downward inflection. These tubes may occasionally cross more than one interlaminar space, and these longer tubes possess thin horizontal tabulae, which are apparently not connected with the horizontal laminae, and slightly thicker walls. Radiating systems of astrorhizae are not present, so that these tubes are probably not vertical astrorhizal canals. The latter, in addition, are not bounded by definite walls. On the other hand, the tubes are of much smaller calibre than "Caunopora" tubes, which have not been observed in this species.

Tangential sections show the cut ends of the isolated tubular radial pillars. Horizontal connecting processes between the pillars are rare even in the laminae, which are apparently compact and structureless. No astrorhizae have been observed.

Remarks.—The skeletal mesh is of the same type as that of *C. striatellum* (d'Orb.), in that the laminae are vaulted between

the pillars, and are fairly regularly spaced. As in *C. striatellum* (d'Orb.) the radial pillars are formed by the downward inflection of the horizontal laminae, but are distinct in form from those of that species. The tangential section is likewise distinct, showing the radial pillars to be hollow and thin-walled.

Horizon and Locality.—Silurian (Yeringian). Mitchell's Quarry, Cave Hill, Lilydale, Victoria. Two examples in the collection of the National Museum, Melbourne. No. 13748 (Holotype), Pres. F. Chapman, Esq.; No. 13749, Pres. C. S. Buckley, Esq., 7.11.13. One example in the collection of the Melbourne University Geological Department, Reg. No. 1448.

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**Explanation of Figures.**

(All figures are enlarged 13.5 times.)

(Figure 5.)

- A.—*Actinostroma compactum*, sp. nov. Vertical section. Coll. National Museum, Melbourne, Reg. No. 13742.  
B.—*A. compactum*, sp. nov. Tangential section of the same specimen.  
C.—*A. verrucosum* (Goldfuss). Vertical section. Coll. Melbourne University Geological Department, Reg. No. 1446.  
D.—*A. verrucosum* (Goldfuss). Tangential section of the same specimen.  
E.—*A. altum*, sp. nov. Vertical section. Coll. Nat. Mus., Melbourne, Reg. No. 13745.  
F.—*A. altum*, sp. nov. Tangential section of the same specimen.

(Figure 6.)

- A.—*Clathrodictyon regulare cylindriferrum*, sub-sp. nov. Vertical section. Coll. National Museum, Melbourne, Reg. No. 13746.  
B.—*C. regulare cylindriferrum*, sub-sp. nov. Tangential section of the same specimen.  
C.—*C. chapmani*, sp. nov. Vertical section. Coll. Nat. Mus., Melbourne, Reg. No. 13747.  
D.—*C. chapmani*, sp. nov. Tangential section of the same specimen.  
E.—*C. calamosum*, sp. nov. Vertical section. Coll. Nat. Mus., Melbourne, Reg. No. 13748.  
F.—*C. calamosum*, sp. nov. Tangential section of the same specimen.
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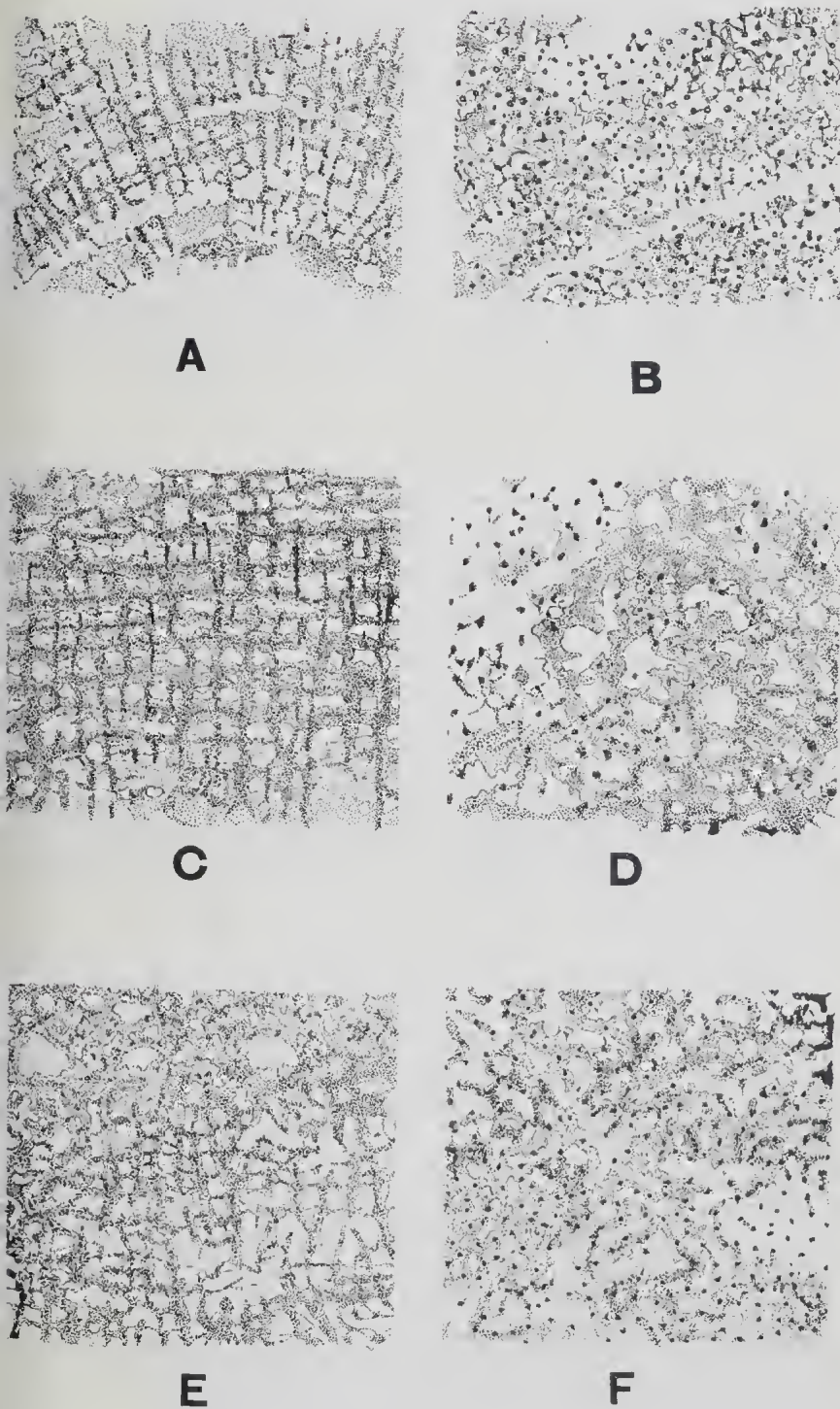


Fig. 5. *Actinostroma* spp.

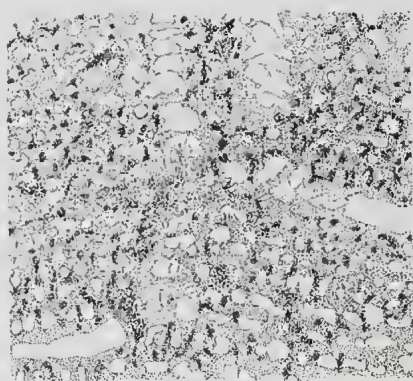
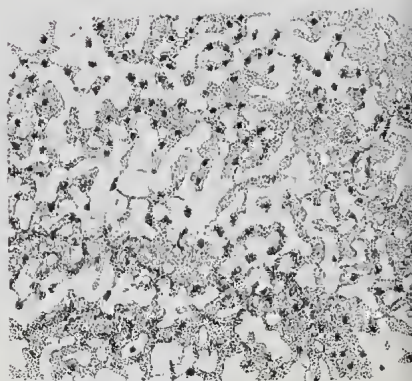
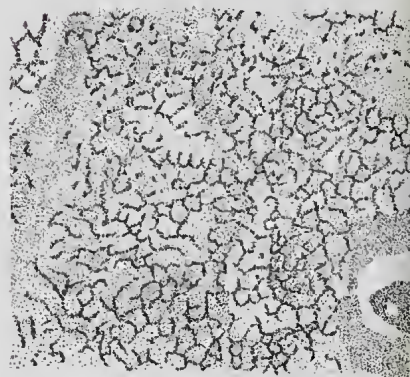
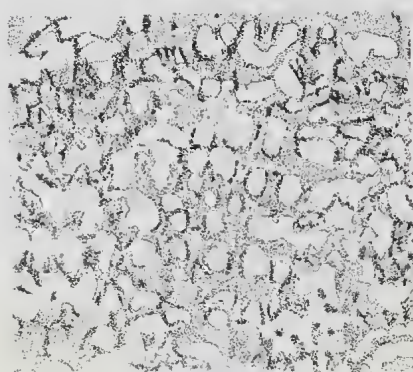
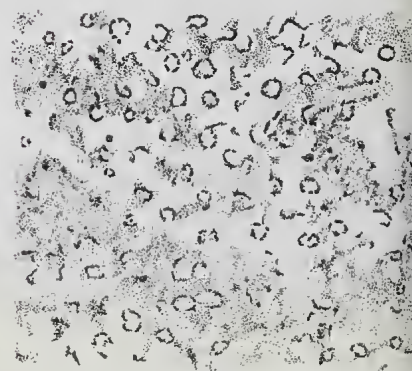
**A****B****C****D****E****F**

Fig. 6. *Clathrodictyon* spp.